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NAVAL AMMUNITION DEPOT
QUALITY EVALUATION AND ENGINEERING LABORATORY DEPARTMENT
CRANE, INDIANA 47522

NADC-9?-/C-1

Evaluation Program For Secondary Spacecraft Cells

ACCEPTANCE TEST OF MCDONNELL-DOUGLAS, ASTROPOWER DIVISION 40.0 AMPERE-HOUR SILVER-ZINC CELLS

QEEL/C 71-436 26 NOVEMBER 1971

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Enclosure (1)

REPORT BRIEF
ASTROPOWER 40.0 AMPERE-HOUR SEALED SILVER-ZINC SECONDARY SPACECRAFT CELLS

Ref: (a) NASA, Purchase Order W12-397
(b) NASA, ltr BRA/VBK/pad of 25 Sep 1961 w/BUWEPS first and FQ-1:WSK of 2 Oct 1961 to CO NAD Crane

I. TEST ASSIGNMENT BRIEF

A. Silver-zinc, 40 ampere-hour, Astropower cells, with an inorganic separator material, were constructed for NASA, Lewis Research Center, under Contract NAS 3-10928. NAD Crane received 64 of these cells for evaluation on the synchronous and Planetary Earth life-cycling orbits and on a wet-stand test. Prior to the placement of the cells on these programs, all the cells except one, serial number 29, which was dissected, analyzed and photographed so that it may be used as a base reference; were subjected to acceptance tests in which each cell was tested for seal quality, physical defects, and ampere-hour capacity as outlined in the acceptance test procedure furnished by NASA Goddard Space Flight Center (Appendix I). This report covers the acceptance test plan of the evaluation program in compliance with references (a) and (b).

II. RESULTS

A. Leakage was detected in five cells prior to the capacity tests and in 19 cells after the capacity tests.

B. There was only one cell which failed to deliver a capacity of 40.0 ampere-hours (cell serial number 107--39.45 ampere hours). The average ampere-hours out on the first and second charge/discharge cycle were 42.41 and 42.18.

III. COMMENTS

A. NASA Goddard and NASA Lewis were informed that 30 percent of the cells were detected as leakers. They then decided that the top portion of the cells be re-potted at NAD Crane to correct this problem prior to the placement of the cells on the various test programs.

RESULTS OF ACCEPTANCE TESTS OF 40.0 AMPERE-HOUR SEALED SILVER-ZINC SECONDARY SPACECRAFT CELLS MANUFACTURED BY THE ASTROPOWER DIVISION OF MCDONNEL DOUGLAS

I. INTRODUCTION

A. The Astropower Division of McDonnell-Douglas developed an inorganic separator material which they incorporated into the construction of 40.0 ampere-hour silver-zinc cells (one cell is shown in Photograph I). NAD Crane received 64, HS-40-7 Series M type cells, fully formed as reported in the NASA technical report DAC-60989-F of November 1970 prepared by Astropower Laboratory, McDonell Douglas Astronautics Company for evaluation on the synchronous and Planetary Earth life-cycling orbits and on a wet stand test. Prior to the placement of the cells on these programs, all the cells except one; serial number 29, which was dissected, analyzed and photographs so that it may be used as a base reference; were subjected to acceptance tests in which each cell was tested for real quality, physical defects and ampere-hour capacity as outlined in the acceptance test procedure furnished by NASA, Goddard Space Flight Center (Appendix I).

II. TEST CONDITIONS

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure.

III. CAPACITY TESTS

A. The average ampere-hours input/output on the first charge/discharge cycle were 42.63 and 42.41, and on the second charge/discharge cycle they were 42.11 and 42.18. Only one cell (serial number 107) failed to deliver 40.0 ampere-hours during acceptance testing and that was during the second cycle when it delivered 39.45 ampere-hours. These results are listed in Table I.

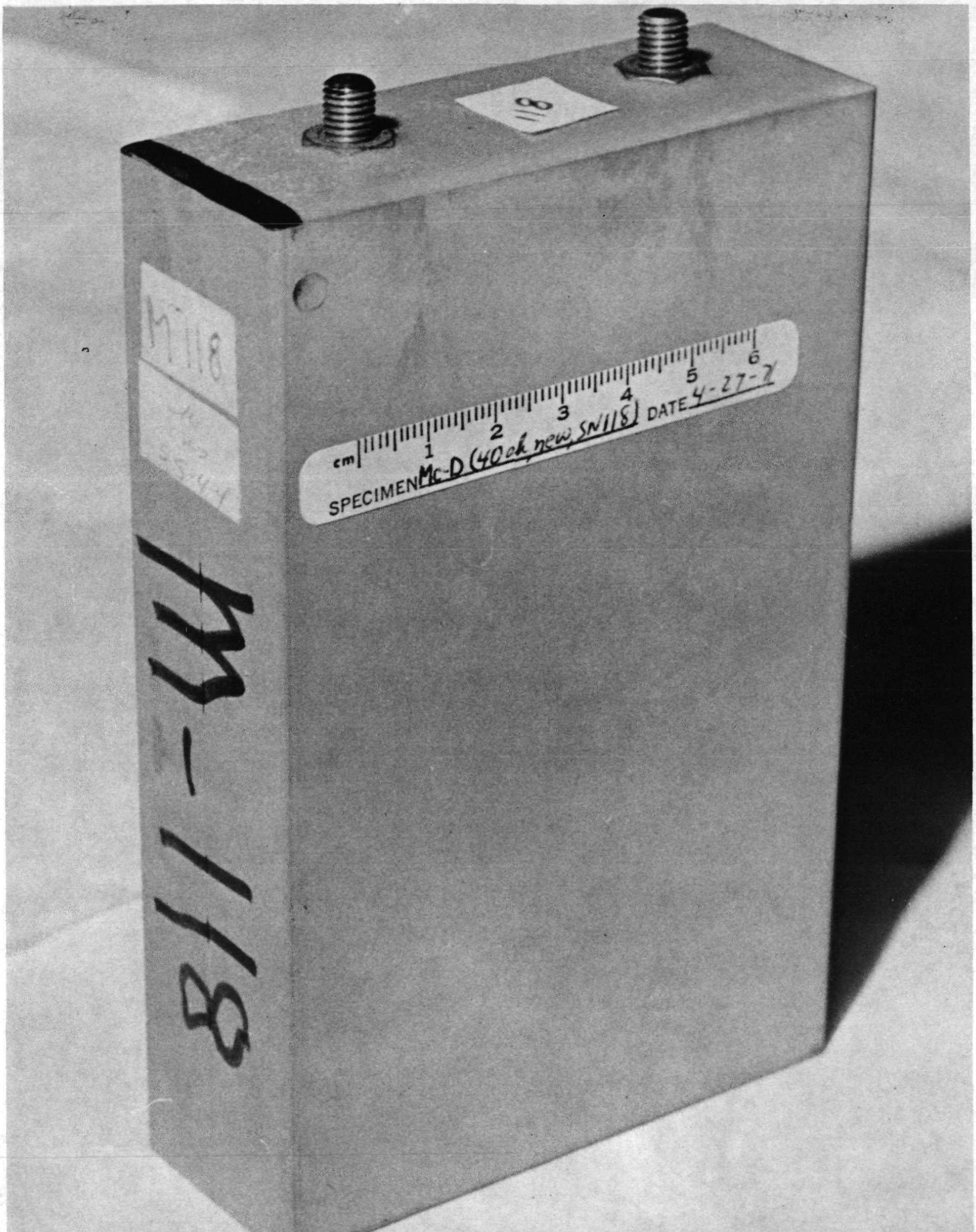
IV. CASE INSPECTION AND LEAK TESTS

A. Visual inspection of the molded plastic case showed no defects before or after capacity tests. Prior to testing, visual inspection showed that five cells had leakage around their terminals and after the capacity tests 19 cells had leaks as detected by phenolphthalein solution. The results of these tests are listed in Table II in which only those cells that leaked are listed.

B. NASA Goddard and NASA Lewis were informed that 30 percent of the cells were detected as leakers. They then decided that the top portion of the cells were to be re-potted at NAD Crane prior to their placement on the various test programs (Photograph No. 2). By re-potting the cells, extension terminals were necessary and the addition of the extension terminals and potting compound increased the height of the cells approximately .500 inch and the weight approximately 58 grams.

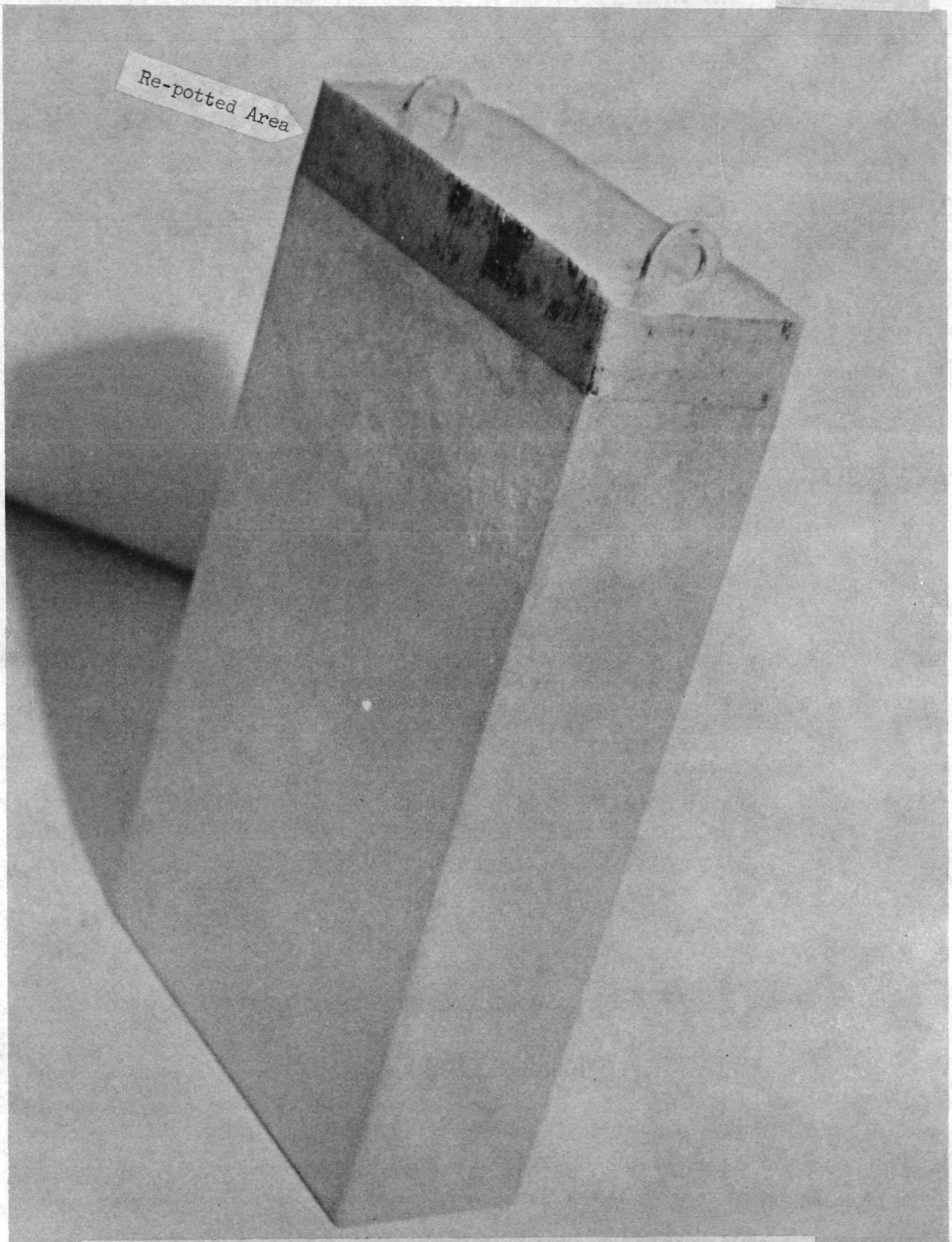
V. PHYSICAL AND WEIGHT MEASURES

A. Each cell was weighed before and after the capacity tests prior to re-potting. The cell dimensions, initial weight, and final weight are recorded in Table III.



Shown here is a new 40 ampere-hour, silver-zinc cell (manufactured by Astropower of McDonnell Douglas) as received, prior to testing at NAD Crane.

PHOTOGRAPH 1



This is a 40 ampere-hour, silver-zinc cell (manufactured by Astropower of McDonnell Douglas) after re-potting upon completion of acceptance testing.

PHOTOGRAPH 2

TABLE I
CAPACITY TESTS

SERIAL NUMBER	FIRST CYCLE AH_{in}	FIRST CYCLE AH_o	SECOND CYCLE AH_{in}	SECOND CYCLE AH_o
24	42.70	43.00	42.00	41.45
25	42.38	42.70	43.48	42.85
26	42.00	42.45	43.45	42.80
27	42.00	42.50	42.75	42.05
28	42.12	42.50	42.90	42.15
29	dissected			
32	42.65	42.85	43.40	42.70
33	42.00	42.50	42.98	42.25
34	42.00	42.50	42.75	42.00
36	42.00	42.45	42.75	41.90
37	42.00	42.35	42.75	41.90
38	42.00	42.15	42.00	42.38
39	42.00	42.40	42.00	42.30
40	43.20	43.40	42.65	43.35
41	44.03	44.15	43.30	44.10
42	43.45	43.60	42.75	43.55
46	42.40	42.55	42.18	42.90
49	43.40	43.60	42.95	43.60
51	42.63	42.85	42.03	43.05

NOTE: Cycles 1 & 2 = 9A to 1.0V + 3A to 1.0V

TABLE I (Cont)

SERIAL NUMBER	FIRST CYCLE AH_{in}	FIRST CYCLE AH_o	SECOND CYCLE AH_{in}	SECOND CYCLE AH_o
52	42.25	42.35	42.00	42.95
53	42.83	42.90	42.35	43.05
54	44.38	42.65	42.20	42.70
55	44.38	42.75	42.00	42.75
56	43.15	41.45	42.00	42.70
57	43.20	41.60	42.00	42.45
58	44.38	42.85	42.00	42.65
59	45.00	43.30	42.30	42.70
60	44.38	42.65	42.30	42.70
61	45.38	43.70	42.00	42.65
62	44.38	42.85	42.00	42.55
63	44.38	42.90	42.00	42.65
64	44.38	44.85	43.13	43.15
65	44.38	44.95	43.23	43.25
66	43.08	42.65	42.53	42.60
67	43.85	41.90	42.00	42.10
68	42.90	42.55	42.40	42.50
69	44.38	44.90	43.40	43.60
70	43.08	42.65	42.43	42.40
71	44.38	44.15	43.10	43.05

TABLE I (Cont)

SERIAL NUMBER	FIRST CYCLE AH_{in}	FIRST CYCLE AH_o	SECOND CYCLE AH_{in}	SECOND CYCLE AH_o
72	43.13	43.50	42.00	42.20
73	42.90	41.85	42.00	42.15
74	42.05	42.15	42.38	41.80
75	40.75	40.65	41.25	40.65
76	40.75	40.70	41.10	40.75
77	41.70	41.00	42.20	41.90
78	42.35	42.25	42.65	42.50
79	42.35	42.30	42.75	42.65
102	42.05	41.85	41.40	41.15
103	40.75	40.80	41.13	40.55
104	40.75	40.80	40.75	40.25
105	40.75	40.85	41.08	40.45
106	41.10	40.90	40.35	40.60
107	40.75	40.95	39.00	39.45
108	41.63	41.60	40.38	40.85
109	42.33	42.25	41.28	41.75
110	42.33	42.35	41.13	41.40
111	42.68	42.50	41.00	41.75
112	41.60	41.65	40.75	41.05

TABLE I (Cont)

SERIAL NUMBER	FIRST CYCLE AH_{in}	FIRST CYCLE AH_o	SECOND CYCLE AH_{in}	SECOND CYCLE AH_o
113	42.33	42.30	40.80	41.15
114	42.75	42.75	41.38	41.70
115	41.10	41.05	40.38	40.75
116	40.12	40.45	42.23	41.90
117	41.75	41.65	43.50	43.05
118	41.75	41.70	43.50	42.73
Average of 63 cells	42.63	42.41	42.11	42.18

TABLE II

LEAKAGE TESTS*

SERIAL NUMBER	INITIAL TERMINAL POS	INITIAL TERMINAL NEG	FINAL TERMINAL POS	FINAL TERMINAL NEG
25				P
26	V	V	P	P
29	V			
32				P
38			P	
39			P	
40			P	
41			P	
46			P	
49				P
53				P
55	V		P	
60	V		P	
75			P	P
76			P	
106			P	
107		V		P
108				P
110				P
113			P	

*only those cells which leaked are listed.
P--Phenolphthalein
V--Visual

TABLE III

PHYSICAL AND WEIGHT MEASURES

SERIAL NUMBER	HEIGHT (INCHES)	DEPTH (INCHES)	WIDTH (INCHES)	WEIGHT INITIAL (GRAMS)	WEIGHT FINAL (GRAMS)
24	5.930	1.350	3.600	875.3	875.3
25	5.946	1.355	3.600	886.5	886.8
26	5.925	1.356	3.604	886.1	886.2
27	5.925	1.349	3.603	890.0	890.1
28	5.928	1.352	3.604	893.5	893.6
29	5.915	1.356	3.607	890.5	
32	5.941	1.355	3.610	890.3	890.4
33	5.938	1.346	3.607	889.8	890.0
34	5.924	1.347	3.600	889.2	889.2
36	5.933	1.348	3.610	888.9	889.0
37	5.932	1.361	3.600	888.2	888.0
38	5.952	1.360	3.600	891.3	891.0
39	5.932	1.356	3.600	892.4	892.2
40	5.935	1.345	3.600	886.9	886.9
41	5.928	1.350	3.600	889.5	889.5
42	5.960	1.352	3.596	891.2	891.0
46	5.932	1.357	3.600	890.2	890.0
49	5.936	1.356	3.600	888.8	886.6
51	5.950	1.355	3.592	891.2	890.9
52	5.925	1.356	3.595	896.0	896.0
53	5.939	1.359	3.594	890.7	890.5

TABLE III (Cont)

SERIAL NUMBER	HEIGHT (INCHES)	DEPTH (INCHES)	WIDTH (INCHES)	WEIGHT INITIAL (GRAMS)	WEIGHT FINAL (GRAMS)
54	5.930	1.355	3.592	886.9	886.6
55	5.931	1.355	3.592	887.0	886.8
56	5.925	1.355	3.600	887.9	887.6
57	5.956	1.356	3.594	886.9	886.7
58	5.950	1.356	3.595	891.6	891.2
59	5.961	1.355	3.598	888.0	887.7
60	5.945	1.351	3.598	887.8	887.5
61	5.946	1.356	3.592	884.0	883.9
62	5.954	1.355	3.600	885.0	884.9
63	5.920	1.355	3.598	885.9	885.7
64	5.946	1.353	3.597	882.3	882.0
65	5.935	1.351	3.593	879.9	879.6
66	5.947	1.348	3.600	882.5	882.2
67	5.965	1.359	3.594	883.3	882.8
68	5.942	1.354	3.590	883.3	883.1
69	5.960	1.360	3.592	887.3	887.0
70	5.922	1.357	3.593	885.5	885.2
71	5.936	1.356	3.590	885.1	884.8
72	5.931	1.354	3.592	887.2	887.0
73	5.954	1.362	3.596	887.6	887.5
74	5.924	1.352	3.593	886.5	886.5

TABLE III (Cont)

SERIAL NUMBER	HEIGHT (INCHES)	DEPTH (INCHES)	WIDTH (INCHES)	WEIGHT INITIAL (GRAMS)	WEIGHT FINAL (GRAMS)
75	5.936	1.352	3.598	890.4	890.3
76	5.950	1.361	3.597	892.1	891.8
77	5.930	1.356	3.593	885.3	885.3
78	5.919	1.355	3.592	884.5	884.3
79	5.933	1.352	3.596	883.2	883.2
102	5.909	1.364	3.590	894.4	894.7
103	5.917	1.354	3.591	891.6	891.6
104	5.894	1.355	3.591	892.3	892.3
105	5.905	1.351	3.593	890.0	890.0
106	5.911	1.359	3.592	890.0	889.7
107	5.914	1.357	3.591	884.5	884.8
108	5.910	1.354	3.592	893.4	893.4
109	5.922	1.357	3.593	880.0	880.1
110	5.905	1.350	3.589	886.4	886.3
111	5.906	1.356	3.595	886.0	886.0
112	5.918	1.356	3.594	878.7	878.8
113	5.911	1.352	3.592	886.0	886.1
114	5.908	1.352	3.589	876.5	876.7
115	5.905	1.352	3.594	891.4	891.3
116	5.909	1.352	3.592	883.4	883.2
117	5.925	1.358	3.590	880.0	880.0
118	5.928	1.354	3.590	892.6	892.6

APPENDIX I

ASTROPOWER HS 40-7 Ag Zn CELLS
SERIES (M-)

ACCEPTANCE TESTS ON ALL CELLS:

1. Inspect cell terminals for corrosion or leaks.

2. Inspect cases for cracks or defects.

3. Weigh all cells within 5 grams.

4. Discharge all cells with 0.5 ohms to 1.0 volts.

5. Assemble cells in 10 cell groups with end plates and connecting rods.

6. Charge at 1.5 amperes to 2.00 volts, each cell. Record cell voltages on first minute of charge and every half hour thereafter. Record Ah in.

7. Discharge at 9.0 amperes constant current to 1.0 volts. Record cell voltages during first minute of discharge and 10-minute intervals thereafter. Record Ah out. After 9.0 ampere discharge continue discharge at 3.0 amperes to 1.0 volts. Record total Ah out for the 9.0 and 3.0 ampere discharges.

8. Repeat steps 6 and 7 once.

9. Ampere-hours out at end of second discharge to be greater than 38.0 Ah. If not, cells should not be used for Sync. Orbit or P.E. Orbiter battery tests.

10. Inspect cell terminals for corrosion and leaks.

11. Weigh all cells to within 5 grams.

12. Assemble cells in 10 cell groups with end plates and connecting rods. The 10 cells for each group shall have similar Ah inputs.

13. Repeat step 6 prior to initiating Synchronous Orbit and P.E. Orbiter Battery tests.

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Gould, Inc. (Dr. C. J. Menard), 2630 University Avenue, S.E., Minneapolis, Minnesota 55414

Grumman Aerospace Engineering Corporation (OAO PROJECT, MR. Steve J. Gaston, Plant 41), Bethpage, Long Island, New York 11714

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Hercules, Inc. (Mr. Paul Cox), P. O. Box 12145, Research Triangle Park, North Carolina 27709

Honeywell, Inc., Livingston Electronic Laboratory (Librarian), Montgomeryville, Pennsylvania 18936

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Life Systems, Inc. (Dr. Richard A. Wynveen, Pres.), 23715 Mercantile Road, Cleveland, Ohio 44122

Arthur D. Little, Inc. (Dr. James D. Birkett), Acorn Park, Cambridge, Massachusetts 02140

Lockheed Aircraft Corporation (Bldg. 157, Dept. 62-25, Mr. Robert E. Corbett), P. O. Box 504, Sunnyvale, California 94088

Mallory Battery Company (Mr. R. R. Clune), So. Broadway and Sunnyside Lane, Tarrytown, New York 10591

P. R. Mallory and Co., Inc. (Dr. Per Bro), Northwest Industrial Park, Burlington, Massachusetts 01801

P. R. Mallory and Co., Inc. (Library), P. O. Box 1115, Indianapolis, Indiana 46206

Marathon Battery Company (Mr. Lou Belove), Kemble Avenue, Cold Spring, New York 10516

Martin-Marietta Corporation (M.S. 1620, Mr. William B. Collins & M.S. F8845, Mr. M. S. Imamura), P. O. Box 179, Denver, Colorado 80201

Mauchly Associates, Inc. (Dr. John Mauchly), Commerce and Enterprise, Montgomeryville, Pennsylvania 18936

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RAI Research Corporation, 225 Marcus Boulevard, Hauppauge, New York 11787

RCA Corporation, Astro Electronics Division (Mr. Paul Nekrasov), P. O. Box 800, Princeton, New Jersey 08540

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Southwest Research Institute (Library), P. O. Drawer 28510, San Antonio, Texas 78228

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